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(54) ELECTRONIC FLASH APPARATUS

(71) We, FRANKE & HEIDECHE G.m.b.H., a German Body Corporate, trading as ROLLEI-WERKE FRANKE & HEIDECHE, of 196 Salzdahlumerstrasse, Braunschweig, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—
The present invention relates to a control circuit for electronic flash apparatus with photo-electrically controlled metering of the amount of light which, when an adjustable threshold value is reached, interrupts the flash discharge by quenching a thyristor connected in the circuit thereof.

In such control circuits, use is made of the very short recovery time of thyristors in comparison to quench tubes (thyatron). For this reason the flash current flow can be arrested at the thyristor with a very brief countercurrent. Nevertheless, the thyristor is very heavily stressed and it is a problem to reduce this load on the thyristor, to prolong the recovery time of the thyristor and to prevent faulty control.

According to the present invention there is provided a control circuit for controlling electronic flash apparatus, including a discharge circuit and a switching circuit, said discharge circuit comprising a storage capacitor connected in series with a flash tube and means for initiating discharge of the capacitor through the flash tube, and said switching circuit comprising a photo-electric integration measuring device, an electronic switch operated by said photo-electric integration measuring device, and a thyristor connected in series with the flash tube and quenched by a series circuit comprising a capacitor, an inductance and said electronic switch thereby to terminate the discharge of the storage capacitor through the flash tube upon the receipt of a predetermined quantity of light by said photo-electric integration measuring device.

Preferably the inductance (μH) lies between

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1/5 and 1/10 of the capacitance (μF) of the switching circuit capacitor.

A constructional embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawing which shows the circuit of an arrangement according to the invention.

The storage capacitor 1 is charged from the power supply via the capacitor 2 and the rectifiers 3, 4 or from a transformer 5. The ignition capacitor 10 is supplied by the voltage divider 7, 8, 9. Ignition results by means of the switch 11 by discharge of the capacitor 10 via the primary winding of the ignition transformer 12. The voltage divider additionally energizes the glow indicator tube 23 which indicates the full charging voltage of the capacitor 1, i.e. operation readiness. The thyristor 13 is connected in series with the flash tube 6. Parallel to the flash tube lies the extinguishing capacitor 14 in series with the inductance 15 and the charging resistor 16. The thyristor 13 is bridged by a resistor 17 so that the point B lies at zero potential in normal condition. The capacitor 14 is charged to operating potential, which appears at point A, via the resistor 16. Between this point A and the base of the thyristor 13 there is connected the series circuit of a capacitor 18 and of a voltage divider 19, 20. The gate of the thyristor 13 is connected to the voltage divider. The series circuit of the capacitor 18 and the voltage divider 19, 20 is bridged by an electronic switch 21 linked to the photo-electric control element 22. This photo-electric control element measures integrally, in known manner, the flash light reflected from the object to be photographed and upon an adjustable threshold value being reached gives an ignition signal for the switch tube 21.

Upon ignition of the flash tube 6 the potential at point B rises from zero and the potential at point A is increased to the same extent. The change of potential at the gate of the thyristor 13 causes the latter to fire whereby the flash tube is connected through.

When the photo-electric element 22 gives the ignition signal to the switch tube 21, the switching circuit capacitor 14—inductance 15—ignition tube 21—thyristor 13 is shorted so that a surge of counter-current develops at the thyristor 13 which surge is of such magnitude and duration that the thyristor extinguishes and, because of its brief recovery time remains extinguished. Since the resistance of the inductance 15 depends upon the differential quotient of the current with respect to time (di/dt), the inductance constitutes a very high resistance at the moment when the electronic switch 21 ignites, so that at first the counter-voltage caused on the thyristor 13 by the discharge of the capacitor 14 is appreciably reduced compared with a discharge without the insertion of an inductance. This prevents a voltage peak which would destroy the thyristor when the electronic switch 21 ignites.

For quenching any thyristor the counter-voltage, i.e. a voltage in the direction cathode-anode must be present on the thyristor for a certain period of time in order that the charge carriers in the barrier layer may migrate off and the *pn*-junction of the thyristor be restored to its blocked state. This so-called recovery time of the thyristor must be taken into account when choosing the capacitance of the quenching capacitor 14, that is to say the greater the recovery time of the thyristor, the greater the capacitance of the capacitor 14 must be if the ohmic resistances in the quenching circuit are the same.

As the discharge process of the quenching capacitor subsides, a counter-voltage is induced in the inductance 15 by the decreasing current flow ($-di/dt$) which tends to maintain the current in the quenching circuit. In this way the current flow in the quenching circuit

and hence the counter-voltage in the thyristor 13 is maintained beyond the discharge time of the capacitor so that the thyristor continues to be supplied with counter-voltage for a short time after expiration of its recovery time and is thus restored with certainty to the blocked state.

WHAT WE CLAIM IS:—

1. A control circuit for controlling electronic flash apparatus, including a discharge circuit and a switching circuit, said discharge circuit comprising a storage capacitor connected in series with a flash tube and means for initiating discharge of the capacitor through the flash tube, and said switching circuit comprising a photo-electric integration measuring device, an electronic switch operated by said photo-electric integration measuring device, and a thyristor connected in series with the flash tube and quenched by a series circuit comprising a capacitor, an inductance and said electronic switch thereby to terminate the discharge of the storage capacitor through the flash tube upon the receipt of a predetermined quantity of light by said photo-electric integration measuring device.
2. A control circuit as claimed in claim 1 wherein the inductance (μH) lies between $1/5$ and $1/10$ of the capacitance (μF) of the switching circuit capacitor.
3. A control circuit substantially as herein described with reference to the accompanying drawing.

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